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Automation of pulp wood measuring – An economical analysis

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Preface

This thesis could not have been written without the help of my family and Stina who have supported me all the way. They have proposed more time for reflection when I have written too fast and given me most appreciated pushes forward when my writing has been standing still. I would also like to thank Lars Lönnstedt and Mats Nylinder at the department of forest products for their knowledge, support and trust in me. I am also most grateful for the contact I have had with the suppliers of automation technique. I am grateful for their sharing information and enthusiasm for the potential for measurement equipment in the Swedish market. Last but not least, I would like to thank all the representatives of the Swedish forest industry who have provided me with information on the pulp industry. This information was necessary to be able to write the thesis. It has been stimulating for a forest student soon to graduate to meet the industry in a positive and helpful way. I have been well received by the representatives of the measurement organizations as well as of the industry, who have invested their precious time in to this study and I hope I have done them some justice.

Abstract

The pulp industry in Sweden has played an important role in the country's economy and still does. It is an energy and raw material-consuming industry with a high degree of industrialization and automation. Much work has been done to reduce labor costs by replacing manual work with technology. In this context, it is remarkable that no precise instrument has been created to help the measurement personnel in their time-consuming work on determining the volume and value of pulpwood delivered to the mills. The delivery to and measuring of raw material at the mills plays an important role in the logistics from the forests to the industry. Measurements have to be performed accurately in order to work as a basis of payment. The way the measurement procedure works today is that one truck has to stand still blocking other trucks when its load is being measured. In the future, it might be possible to speed up this procedure and reduce the manual work with automated measurement. However, transforming an acknowledged method is no easy task, it costs money and patients. For this reason it would be of interest to see whether it would be worth making the effort and whether it would be in the interest of the industry to adopt the new technique.

The aim of this thesis is to determine what benefits that exist when it comes to automation of pulp wood measurement and to determine the possibility of gaining these benefits when installing the equipment. Investigations were made at seven mills. The collection of data for the calculations was made by means of interviews with a standardized questionnaire mailed in advance to the respondents. The respondents were personnel at the pulp mills and in the wood measurement organizations. These data were then processed in order to make net present value calculations and sensitivity analysis possible.

The calculations show that the investment is beneficial even with hard constraints in investment horizon and cost of capital. According to most respondents the benefits discussed are possible to realize. The laser measurement can be installed and adapted to Swedish conditions with benefit for most plants. The risks that can have an impact on the outcome of an investment are much due to the new and in Sweden almost untested technology. Because of this there is a risk in the start up phase and how easy the technology fits in to the measurement regulations that exists today. The forecast for the implementation of this new technology however looks good. To get leverage to the investment it is of importance not only to try to adapt the new technology to the circumstances today but also be willing to adapt parts of the measuring to gain extra effect of the new technique.

Key words: laser measurement, net present value, sensitivity analysis, Swedish pulp industry

Contents

1 Background

In this chapter, a brief background of the topic is presented together with the relevance to the pulp industry in Sweden today. Additionally, the purpose of the thesis is presented.

1.1 Introduction

The pulp industry in Sweden has played an important role in the country's economy and still does. The forests are still the foundation of a wealthy industry. In 2006, exports of wood products were worth SEK 120 billion and the import value for Sweden for the same category of products was SEK 25 billion.[1] No other industry makes a larger contribution to the Swedish current account balance. It is an energy and raw material-consuming industry with a high degree of industrialization and automation. Much work has been done to reduce labor costs by replacing manual work with technology. In this context, it is remarkable that no precise instrument has been created to help the measurement personnel in their time-consuming work on determining the volume and value of pulpwood delivered to the mills. Today, we may have reached the point where a step towards a higher degree of automation in the measurement procedure is possible. The delivery to and measurement of raw material at the mills plays an important role in the logistics from the forests to the pulp mills. Measurements have to be performed accurately to work as a basis of payment between seller and buyer and it has to be time efficient so as not to create a bottleneck in the flow of raw material to the mills. Making logistics accurate is a complex matter. The ones responsible often feels pressure from the mills, which want certain volumes at certain times, the forest contractors who have limited possibilities due to weather conditions in combination with limited resources, and from the logistics companies for the same reasons. Because of these factors a bottleneck adds costs and tension to the logistics chain. The way the measuring procedure works today is that one truck has to stand still, blocking other trucks while its load is being measured. In the future, it might be possible to speed up this procedure. It might also be possible to accumulate some of the measurement work from times with many deliveries to times with fewer deliveries and in this way even out the workload. This would cut the peaks, making the work more productive and reducing the bottlenecks. However, transforming an acknowledged method is no easy task. It costs money and patients. For this reason it would be of interest to see whether it would be worth making the effort and whether it would be in the interest of the industry to adopt the new technique.

1.2 Aim

The aim of this thesis is to determine what benefits that exist when it comes to automation of pulp wood measurement and to determine the possibility of gaining these benefits when installing the equipment.

1.3 Implementation

The main goal of this thesis is to give a correct description of how the pulp industry in Sweden would be affected by an investment in automation of raw material measurement. To make this possible, information had to be collected from a number of actors in the Swedish pulp industry. In the initial phase, the focus was on obtaining a good overview of the pulp plants in Sweden. The aim was to determine their consumption of raw materials and their geographical location. The collection of information on the pulp mills started with a market overview carried out by Woodtech MS. The market overview was then modified and updated

[1] Rennel 2008

by means of an intensive search of the pulp mills websites, the organisation Swedish wood industries website (Skogsindustrierna) and with the help of Torbjörn Andersson at department of forest products, SLU Ultuna. The aim was to calculate the number of pulp mills and then use the results to estimate the value of the whole industry. The collection of data for the calculations was made by means of interviews with a standardized questionnaire mailed in advance to the respondents. The respondents were personnel at the pulp mills and in the wood measurement organizations. These data were then processed in Excel to make an economic analysis possible.

It was necessary to know the size and design in order be able to make statements about how the industry would be affected. Questions that had to be answered were, how many pulp plants there are and what volumes of raw material each industry receives. The pulp and paper industry today is a unstable market with changes in production volumes and plant closures. This made it impossible to use old databanks of information and it was necessary to search for the true figures from various reliable sources such as updated figures from the company's websites, the Swedish wood industries' website[2] and the wood measurement association.

1.4 Limitations

This thesis has been written in order to determine the benefits of an investment in laser measurement equipment for Swedish pulp mills. Investigations were made at seven mills. The results of the investment analysis are specific for each plant. They can, however, serve as a guideline for how a mill situated in the same region and of the same size as one in the thesis, could benefit from an investment in laser measurement equipment.

[2] Skogsindustrierna 2006

2 Wood measurement methods

2.1 Pulp industry measuring

There are several existing ways of measuring wood used by the pulp industry. There is an ongoing struggle to combine cost effectiveness and accuracy. This chapter contains a short presentation of the methods most often used, their advantages and disadvantages. The most common measurement in Sweden in the case of pulpwood is the determination of solid volume. In the north, a form of weight measurement is more common. This will be discussed under geographical differences. In the case of imported volumes, weighting is the most frequently used method. The issue of future measurement methods will also be addressed at the end of this chapter.

2.1.1 Solid volume

The most commonly used method in Sweden for determining payment of transaction of pulpwood between seller and buyer is the solid volume excluding bark. The solid volume is determined by measuring the frame volume and estimating how much wood the frame volume consists of. This is done by experienced VMF personnel at the mill's receiving unit. In Sweden, the unit for payment is solid volume beneath bark, so to determine the price of a load one must also extract the bark. The abbreviation of cubic metres solid volume excl. Bark is = m3f ub.[3]

In Finland, solid volume is also used but there the volume on bark is used and consequently one subjectively determined factor is excluded. The abbreviation of cubic metres solid volume incl. Bark is = m3f pb. There has been a discussion in Swedish media about changing the unit for payment to volume including bark. In this discussion, important representatives of development in Swedish wood measurement have made statements that elucidate some of its benefits.[4]

Volume is not the perfect unit to determine payment since a higher volume does not necessarily mean more wood fiber for the industry. Fast-growing trees increase fast in volume but tend to have lesser fiber content per unit of volume than slow-growing trees.

In the sawmill industry, the most common way of measuring the raw material is log by log. However, a substantial proportion is measured in stacks on the trucks. In 2006, the volume measured in stacks was 8.9 million m^3 of solid wood out of a total volume of measured saw logs of 38.9 million m^3 of solid wood, i.e. 22 %.[5]

2.1.2 Weight

Another commonly used method for measuring wood is by weight. The delivered wood is weighed at the mill to determine payment. Since the unit of payment is solid volume under bark in Sweden, conversion figures are used to convert the weight into solid volume. These figures are based on experience and have been developed by carefully studying the variations in the weight/volume correlation.

There are pros and cons with every method used and there is no clear choice in transactions involving pulpwood. The industry wants to quantify and pay for the consistency of wood

[3] Virkesmätningsrådet 2008
[4] Ostelius 2009
[5] Virkesmätningsrådet 2006

fiber. There are also occasions when the plants demands as recently harvested wood as possible, especially for Thermo Mechanical Plants (TMP) and Chemical TMP plants (see 3.1.4for a description). Wood from Swedish spruce and pine consists of approximately 50% water[6]. The raw material, however, always varies over time so there is no linear relation between weight and volume[7].

2.1.3 Solid dry density

Interest in dry density is growing in the Swedish pulp industry[8]. Dry density is the weight of 100 % dry wood divided by the volume of wood. This method is used to determine the density of the delivered wood in a dry state. The unit is a fair base for payment of the wood since it takes into account the factors important for the yield of the raw material. However, today it is a complex and expensive procedure to determine the correct dry density. To determine percentage of moisture, one has to take samples from a representative amount of the load of pulpwood. The samples are weighed and then heated up to the point where all moisture has disappeared. The samples are then weighed again. It is then possible to state how much water the load contains. This knowledge plus a correct figure for the total volume of the load are a good basis of fair sales of pulpwood.

2.1.4 Industrial differences

There are differences in the pulp manufacturing that influences raw material logistics. In the context of this thesis, the plants are divided into two categories: TMP/CTMP plants and chemical pulp plants, such as sulphate and sulphite plants. One difference is the exceptional need of fresh pulpwood for the TMP/CTMP plants. The extra processing cost for wood that is not fresh at Holmens mill Hallstavik is 25-50 sek/ m³f ub.[9]

The plants consume the same amount of wood constantly and have to be provided with this wood in order not to come to a standstill. Since the lock up of capital in pulp mills is considerable, an expensive stoppage due to a lack of raw material is not an option. For the pulp mills, quality and production stability are very important. One of the most important factors for production is the raw material. This varies over time, which disrupts the processes in the mill. There is a substantial amount of money to be saved by improving control over the process.[10]

There are seasonal effects that hinder the optimal flow to the industry. Because of the impact of the climate and the temperature on roads in the transition from winter to summer, there are problems delivering during the spring. Another issue in the supply of wood to the plants is the summer vacation for employees. One example is the plant Hallstavik which wants to constantly receive fresh wood. The difference of received pulp wood in m³f ub between July 2000 and March the same year was 71% f ub.[11]

2.2 Sweden today

Wood measurements in Sweden are carried out by three independent wood measurement associations (VMFs) divided into three geographical areas. These three, VMF Nord (north), VMF Qbera (central) and VMF Syd (south) act as guarantees of equal and fair measurement

[6] Lehtikangas, p. 10
[7] Sikter, Karlström, Sandberg & Engstrand 2008, p. 305
[8] SDC 2004, p. 21
[9] Kogler 2004, p. 16
[10] Sikter, Karlström, Sandberg & Engstrand 2008 p. 305
[11] Kogler 2004, p. 14

between buyer and seller.[12] When it comes to measuring wood, different methods are used depending on what's important for setting the price.

Raw material for pulp is most often measured manually on trucks. An operator measures the frame of the cargo with a large shift-calliper and estimates the amount of solid wood and occurrence of rot and bark since the standard for payment is solid wood volume under bark. To further enhance the precision of the measurement, a fixed amount of 1‰[13] of the wood is measured log by log. The deviation between what was estimated in the former method and the exact manually measured volume is then used to calculate a translation number that is used for the total volume the unique operator has measured.

This procedure of manually measuring the load, making notations of bark thickness, rot and occurrence of unwanted material in the cargo, and then reporting the information to the forest industry IT company (SDC) takes approximately 10 – 15 minutes[14]. All information collected by the measurement organisations is transferred to Timber On Line (VIOL), a network linking all the actors in the wood market. This network was created and is maintained by SDC, which stores all the data used in timber transactions[15].

2.2.1 Geographical differences

There are regional differences in measurement methods in Sweden. The differences are due to differences in forest owner structure and specifications for the grown raw material. In the north, there are few small private owners that sell to the pulp industry. Larger collectives and forest industries are more common. This means that a correct measurement of each bundle of wood is of less importance. The focus is on cost-effective measurement providing exact figures for larger quantities than in the south. This means that VMF North can use test samples instead of precise bundle measurement and still be able to arrive at the same or lower standard deviation per total measured volume.[16]

As regards the homogeneity of the raw material, the most northerly parts of Sweden have much less deviation in wood characteristics. This enables VMF to weigh the loads with acceptable precision and by means formulas calculate the estimated volume based on the weight information. This procedure is called "5:2 measurement" and is used in the most northerly parts; there is also an agreement to use this method on imported volumes.[17] This method is much faster in addition to being precise. The preciseness of the method makes it possible to reduce expensive sampling measurements. The cost of sampling in 2006 was SEK 63 per m³ solid volume under bark in the northern region and SEK 87 per m³ solid in the Qbera region.[18]

However, a new technology for exact measurement of the samples is being tested in the Qbera region. The Mobile Automated Log measuring (MAS) project consists of log-by-log laser measuring equipment mounted on a truck, which makes it mobile. This truck circulates among the plants in the region and carries out effective measurements of the bundles that have been randomly selected for control measurement. This equipment will probably make control

[12] Virkesmätningsrådet 2003
[13] Adolfsson 2009 (Mail correspondence)
[14] Adolfsson 2009 (Mail correspondence)
[15] VMF Qbera 2006
[16] Weslien 2009 (Oral communication)
[17] Weslien 2009 (Oral communication)
[18] Virkesmätningsrådet 2006, p. 39

measurement less expensive in the future. This machine was developed in the Qbera region and after approval by VMR in 2006 will probably be produced in larger numbers.[19]

There is a difference in the cost of the total measured volumes between the different geographical regions. In 2006, the total cost per m³ of solid volume excl. bark for all measured volumes was SEK 2.66 for the northern part and SEK 4.01 for the southern part. One difference between the regions is, as has been mentioned, that the southern region uses 99% stack measuring and the northern only 28% stack measuring and mostly the 5:2 method.[20]

2.3 Automation method for Sweden

Lasers for measuring logs have been used in the Swedish forest industry for a long time. This measurement technique has so far been focused on single-log measurement. Today, it is used to describe single logs in the measurement and posting procedure in sawmills. In this way, it has been possible to increase profits in the sawmill industry and make measurements more effective.

The pulp industry in Sweden has so far not adopted the laser technique for wood measurements. In other pulp industry intensive areas, such as South America and Finland, laser measurement technology is frequently used to facilitate the procedure and make it more cost effective. The equipment that functions as a basis of the calculations used in this thesis is supplied by Woodtech measurement systems in Santiago Chile. They have provided numerous plants in Latin America with laser measurement systems and have been willing to share information about how their equipment, Logmeter 4000, works and what it could achieve in Swedish conditions.

It could be said, with some reservations, that the laser for measuring pulpwood functions in a similar way to the ones commonly used for saw logs measurement. The difference lies in the fact that the volume-measuring lasers measure complete truck loads one at a time. When a truck deliver raw material to a mill, it drives through a frame with lasers directing laser beams from three directions at the cargo. Since the speed of the truck is also registered, the instrument knows how long the cargo has moved between each beam sent out. This makes it possible, with the help of a computer, to draw the cargo three dimensionally and make volume calculations. The total time for the truck to drive through is approximately 1 minute. It is not technically possible to drive faster than this, at present, without causing deviating results from the measurement process. The laser does not “see through” logs since it works because beams bounce off the surface. It models the load by calculating the time it takes for the beam to bounce back. This results in a calculation of the whole load with the frame logs of the load as a base. By means of repeated tests and sampling of loads it is possible to make estimations of the content of the whole load from the data collected from the frame logs. This is done by means of formulas that are entered into the software, which then convert the data received from the laser measurements.

According to the manufacturer, one measurement station with one operator each shift during day time could handle 200 trucks per day. This includes the evaluation of bark, rot, snow and other factors that would still have to be done manually. Other factors taken in consideration

[19] Virkesmätningsrådet 2006, p. 4, 17
[20] Virkesmätningsrådet 2006

when estimating the number of trucks is the examination of the cargo to ensure that it only contains wood and not material harmful to the pulp process, such as coal, plastics and metal.

2.3.1 Start-up time

Since the technique is more or less new for Swedish conditions, the start-up will probably be longer for the initial plant than for the subsequent installations. As the aim of the thesis is to present figures for the industry, the time consumed for the first installation will not be taken into consideration. It could take approximately one year from the initiation of the process to an up-and-running automatic measuring station.[21] A standard installation, with the first test runs and formulas for calibrating the measuring, has already been carried out, which means that it would be possible to install and start up a measuring unit in 6 months.

2.3.2 Benefits under Swedish conditions

The aim of this thesis is to determine the benefits of an automation of the measuring system in Sweden and to make estimations of the monetary value of these benefits. In this section, a presentation is given of the hypothetical and known sources of savings from automated measuring. A number of these were selected and presented to the personnel interviewed at the pulp plants in this thesis and to the VMF regions' personnel. The results from these interviews and how they were evaluated from a Swedish perspective are presented under mapping of monetary and non-monetary results chapter 5. I will also return to the possible benefits to the Swedish forest industry in the discussion of the results. There are differences when it comes to what and how big the benefits are for the pulp plants in Sweden due to their varying production, size and raw material requirements.

One benefit of the automation method is that the measuring procedure is faster than the manual method. This reduces the time trucks spend on delivering wood to the industry. It also reduces the unwanted queues that occur in the measuring stations when more trucks arrive at the mill at the same time than the measuring personnel have the capacity to measure. Both these aspects result in more time for the trucks on the roads and less time standing still at the mill.

Automated measuring makes the work of measuring a truck faster and easier for the personnel. There is still a need for human monitoring and for notifications of rot and bark thickness. Automation will save time for the people measuring wood, thus making it possible to adjust the workforce to these more time-effective technical tasks compared with manual hands-on measuring of the trucks.

Today, the raw material delivered to the pulp plants has to be measured at the same time as the truck arrives at the industry. With a system that records all the necessary data for determining the volume of the cargo, it would be possible to receive trucks 24 hours a day but process the data only during daytime. In this way, the more expensive and inconvenient work during the night shift could be moved to the day shift.

There are problems with reducing measuring work during the night, which will be discussed later. The industry in some places wants the measuring to be carried out simultaneously. It is still possible to reduce nighttime measuring. The method might be a little unorthodox for the Swedish wood industry. Hospitals in Sweden have outsourced the examination of X-ray plates to companies in Australia. This means that Swedish specialists can simultaneously analyze the

[21] Yourston 2009 (Oral communication)

x-ray plates and still only work during the day since they are situated on the other side of the world. This could also be possible for measuring pulp wood.[22]

Automated measurement equipment would record and store a large amount of data on the raw material delivered to the mill. This would be accessible at any time to the production or planning unit at the mill. Examples of stored information could be quantities of each diameter, narrowing of the stems and source of raw-material, thinning or final cutting. Much of this is already recorded at some plants. The difference would be that it would not require any extra time or money to collect the data and when it comes to e.g. the diameters of the logs and the narrowing of the stems it would probably be more exact. Since the measuring would be more exact, control over the stock would also increase which is beneficial, especially for those mills that have a low buffer of raw material. To summarise, the production unit would have more data recorded on the deliveries to the mill. This would make planning easier and more exact for production.

When making less of the measuring manual, it is easier to determine the deviation in the errors made and the exact repeatability of a machine is much higher than of a human. If the machine measures a load a little too high quantity or too little, it will make the same error if the same load is measured once again. This makes it possible to take fewer samples of volumes measured by the machine and still have the same standard measuring deviation as a whole.

To be able to use automatic measuring in Sweden, it has to be as good or better than manual measuring. The potential for automatic measuring with correctly adjusted formulas that have been developed over time with regular control measurements and inputs is better than what is achievable within the time frame today for manual measurement. This makes it possible to keep a close eye on the amount of wood delivered to the mill and is a good way to control the volumes in stock. For some mills short-term planning of the harvesting and transportation rate is dependent on exact knowledge of the round wood in stock, especially those TMP/CTMP mills that are in need of newly harvested raw material. It is always advantageous for an mill to have a correct estimate of stock in order to keep track of tied up capital.

[22] Dagens Medicin 30-05-2007

3 Capital budgeting methods

Making investment calculations is one way of facilitating the decision-making process in companies when planning changes for the future. There are, however, other factors such as intuition that also play an important role. The mathematical calculations are often models used to verify intuition[23] Since the calculations themselves have no value before they are interpreted by the persons making the decisions, it is of great importance that the persons making calculations choose methods known and accepted by the persons making the decisions. According to both Copeland[24] and Löfsten[25] the most frequently used methods today are the Net Present Value (NPV) and Payback period. These methods are not comprehensive in their description of the results of an investment. This will be described in greater detail in the following chapter. They are, however, a good basis for decisions. A more modern approach to the investment decision-making process is Real options. Real options is a less static approach that handles variations and possibilities better than NPV and it is wise to keep the ideas of the Real option method in mind when analyzing the results of this thesis. There are various ways of handling risk in an investment. The cost of capital is based on three factors: compensation for waiting, loss of buying power and compensation for risk[26]. One common way of tackling the risk aspect of an investment is to raise the cost of capital in the equation[27]. Since this thesis includes calculations involving different companies with varying capital costs, it would not be justified to either raise or lower the interest overall since the companies view the investment in different ways. Another way of handling risk in an investment calculus is to perform a sensitivity analysis[28]. This makes it possible to somewhat circumvent the static NPV calculations and risk handling dilemmas; this will be described in greater detail later.

3.1 Economic concepts

The cost of capital or the opportunity cost of capital is the best return on invested capital an investor can find, at a given risk rate, with the future cash flows discounted back to the day of investment. If the investment has a high risk, the expected investment rate also has to be high to compensate for this. An investment regarded as risk free will have an interest rate as low as a normal interest rate on national state bonds. [29]

3.2 Payback period

Payback is a very simple calculation method. Normally used in an initial step to determine whether it is of interest to proceed with a project or to make a selection from a large number of alternatives.[30] Making a payback time analysis is a way of analysing the risk of an investment. It is easier to foresee the near future than the more distant future. If the payback time is to be considered very long for a project, there is a higher risk because of the problem of obtaining reliable data. If the payback time is shorter, one can most often rely on the input data.

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23 Copeland & Antikarov 2001, p. 52
24 Copeland & Antikarov 2001, p. 56
25 Löfsten, 2002
26 Yard 2001, p. 25
27 Löfsten 2002, p. 152
28 Yard 2001, p. 70
29 Berk & DeMarzo 2007, p. 141
30 Löfsten 2002, p. 41

To use payback period as an guideline to investments, one must first calculate the cost of a project and then the anticipated income for that project on an annual basis. With these figures, it is possible to determine how long it would take for an investment to be paid off, the payback period. If the period is short, it is considered to be a good investment and if it is long, it is considered to be a more risky and unsure investment.[31]

3.3 Net present value (NPV)

The present value of money is considered to be what a future benefit or cost is worth today. NPV is a commonly used method for investment analysis. It uses the company's discount rate and anticipated future cash flows to determine whether an investment will develop a positive return, taking into account the company's cost of capital. The discount rate is the minimum interest rate the company demands on invested capital given a certain risk. This rate could vary for many reasons. If it is difficult or expensive to raise cash for investments, the rate of discount will go up. If an investment of money in capital markets results in a low return on capital because of low general interest rates, this alternative will be less attractive for investors and therefore also lower the interest rate threshold for when other investment alternatives becomes more attractive. To use the NPV model, one must have knowledge of the cost of investment and future cash flows contributed by the investment.[32]

The formula used is NPV = Present value (Benefits) – Present value (Costs)

If a NPV calculation gives a zero return, this indicates that an investment would give the exact return according to the rate of interest required by the company. With this result, a company can make the investment without impacting on its ability to pay interest on invested capital. The company becomes larger but the valuation of its stocks price does not change.

3.4 Weighted average cost of capital (WACC)

Weighted average cost of capital is the most common method in investment calculus. This, however, implies, as stated in the theoretical section, that the investment at hand has the same level of risk as an average of the investments made by the company. Consequently, it is of interest to investigate how the managers view an investment of this kind and use their interest rate for the thesis.

Net present value is a more advanced calculation method than the payback period. The net present value shows if the investment will be paid off during the economic lifetime of the investment. In the sensitivity analysis performed, different economic durations of the investment are tested. This gives an indication of when the investment will be paid off. In this thesis, the net present value gives more information about what an investment will mean for a mill and will therefore be the method used in this thesis.

3.5 Sensitivity analysis

Sensitivity analyses are used to see how variations in important inputs in a calculation affect the outcome. The normal procedure is to find the average and most likely combinations of inputs in the investment calculation. The values that could vary in reality are altered one at a

[31] Berk & DeMarzo 2007, p. 152
[32] Berk & DeMarzo 2007, p. 54

time in the calculation. With this method, it is possible to evaluate the span of uncertainty that exists in the calculation. It can also indicate what fluctuations in the analysis of the future are tolerable for a positive outcome. This method is, however, in some respects insufficient. For example, it is possible that there is more than one variable change at a time which is difficult to handle with this simple method. It is possible to perform a Monte Carlo analysis, which is a program that runs different scenarios automatically. This, however, requires a lot of time and programming to get it right. [33]

Regarding the size of this work, it has been estimated that a NPV with a sensitivity analysis is an adequate mathematical method. This limitation makes it possible within the time frame to also look at non-numerical values that emerge in the qualitative part of the interviews. Even though combinations of changing variables are not used, the analysis is still a good tool to estimate the size of the impact on the result of a change in the different variables.[34] The investment calculations are based on a varying amount of data, some more reliable than others. The data are also of varying importance for the outcome of the investments. The sensitivity analysis is a good way of finding the key cornerstones. The indicators that are used are the variables that are most important for the outcome. This could be both because they are hard to predict or can vary a lot and because they are so important for the calculation that a small change in the value results in a big difference in the result. The key indicators for these calculations will be presented in Chapter 6.1.

3.6 Tax and inflation in investment calculations

In a perfect market, a company's capital structure is unimportant but since taxes and transaction costs exist we have an imperfection in the market economy. To handle this imperfection, wise companies can raise their value by using leverage to minimize taxes.[35] Taxation and the existence of inflation can, in an investment calculation, result in significantly different values compared with if these aspects are neglected. However, as several companies will be investigated in this thesis and time is limited, the focus has not been on the financial issues of each of these companies. In the thesis, neither inflation nor tax has been taken into account in the calculations. This decision has been made in order not to add more uncertainty than necessary to the calculations and to allocate the most time possible to investigating the actual effects of an investment.

[33] Trigeorgis 1996
[34] Berk & DeMarzo 2007, p. 199
[35] Berk & DeMarzo 2007, p. 460

4 Method

This chapter describes how the selection of respondents was made, the methods used for collecting the information and how the information collected will be presented in the thesis. This chapter also includes a method discussion in which the reliability, validity and the possibility of generalization will be discussed.

4.1 Sampling

On the basis of the data collected, pulp mills were selected for the interviews. The goal was to select plants with varying basic conditions. Important aspects were that the plants selected would display a variation in size and geographical location because of differences in the north and south of Sweden. Variation in size was preferable because there is an initial fixed cost of the automation equipment. This makes an investment less profitable with lower volumes of measured volumes per year. The geographical spread of plants is due to differences in measurement methods and the presence of more snow in the north, which could possibly affect the investment scenario. There were also other factors present that affected the sample made. Some of the information that the companies shared for the calculations was not of the kind that is normally displayed to persons outside the company. To make it possible to gain access to the information, there had to be validity in the approach made to industries to assure them that this thesis could generate information that would be useful to them.

Because of these prerequisites a so-called snowball method[36] was used. When using the snowball method, the first person contacted leads to the next because of a relation between the two. When you are able to refer to a known contact person, it is easier to gain access to valuable information and cooperation from the next individual contacted. The main objective of having a variety of plants was interlaced with the snowball method to be able to obtain the information needed.

Holmen, Södra and Sydved were selected using the snowball method, one contact led to another. The first company contacted was Holmen because its interest in laser measurement was known by Professor Mats Nylinder at the department of forest products SLU, Ultuna. Contact was then made with a number of companies with smaller mills in order to satisfy the predetermined criteria. One mill owned by Nordic-Paper responded positively. After a review of the companies contacted, it was evident that mills in the north of Sweden were not sufficiently well represented. Accordingly, SCA, M-real and Billerud, which have pulp mills in the northern regions, where contacted. Two of them responded positively. In total, seven mills were studied, two in the southern region, three in the central region of the Qbera measurement organisation area and two in the northern region. The geographical spread is acceptable. The central region, with three mills represented, is also the region with the largest total consumption of pulp wood. The variation in size of the plants regarding yearly intake of round wood is good. However, there could be a better representation of small pulp mills. The variation in round wood intake between the mills is presented in Figure 1.

[36] Kvale 1997 p, 177

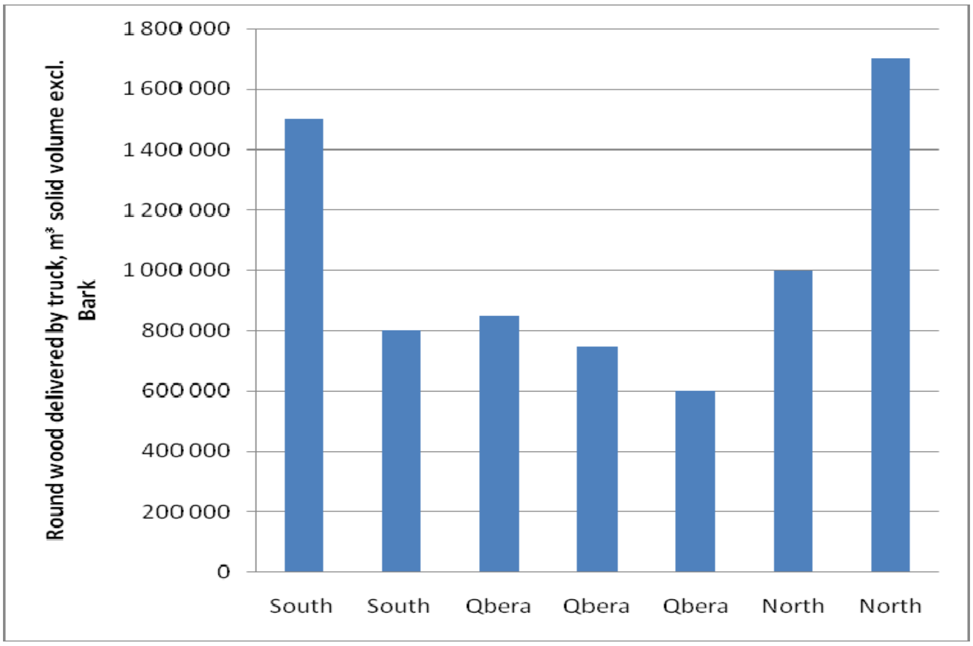

Figure 1. Distribution of roundwood intake per plant and region.

Apart from the pulp mills, important information was also needed from measurement associations involved. In the search of information, the first person contacted was the head of the national wood measuring council's development section (VMU). Subsequently, contact was made with all three existing measurement associations. The selection of whom to interview at the different associations was made on the basis of recommendations from VMU. In this way, contact was made with the right persons at each association.

4.2 Interviews

The collection of data was divided into two parts. There are a number of different aspects that have to be measured to cover all possible benefits of automated measurement equipment. Some of these are easy to determine, such as how much is gained in time per truck when a laser automation method is used to measure volume. There are, however, more intangible values for a new measurement technique, such as "will there be benefits in production for the plant if it receives more and precise data on the raw material in stock". The extra data could, for example, be how many stems of each diameter there are in stock or how many crooked stems there are in stock. This information could be advantageous. It is unfortunately very hard to estimate these benefits so that they can be included in the calculations. Accordingly, the questionnaire was divided into two parts with one covering measuring at the mill today. This part was then compared to how it would be with automated measuring and was used for the calculation since the answers were given in numbers. The second part was more explorative without a search for answers in numbers. In this part, the respondent was given the opportunity to develop his/her answers concerning e.g. benefits in production. The results of these questions were not added to the calculations since it is hard to determine their effects in advance. Instead, they are presented in a separate chapter. This part aims to give a qualitative description of the respondents' tasks, which could be affected by automated measurement.

When it comes to qualitative investigations, the interviewer must be able to create a secure atmosphere in which the interviewees share opinions and answer questions in a free way and do not leave out any aspects[37]. In this thesis, a semi-structured approach in the interviews was employed. This means that some questions in the questionnaire were determined in advance but that there were also room for follow-up questions. In this way, it was possible to make the respondents feel that their opinion was important and, because of the follow-up questions, that the interviewer had knowledge of the business and was interested in the subject. Thorough preparations were also made. This included learning about the work and systems for wood measurement procedures in the pulp industry. As a result, the respondent hopefully regarded the interviewer as a qualified receiver of data, so that from the beginning of the interview the respondent thought of the situation as being beneficial.

As regards the qualitative part, the approach to searching for data changed somewhat during the interviews. When conducting qualitative research interviews, there are two possible theoretical perceptions of the work. These are categorised as “the ore searcher” and “the traveller”. The ore searcher has the perception that there is one true and accurate answer to a question asked and a set of data that is possible to find if you search in the right way. The traveller sees himself more as strolling around in his search for data and describing the environment as it passes by. In contrast to the ore searcher, he finds that one question follows on another and that they are all linked and dependent on each other. According to the traveller, there is no “true” and unbiased answer to a question.[38]After the first quantitative set of questions regarding received raw material volumes and number of trucks delivering per day, it was easy to continue the qualitative part of the interviews using the same approach. This was the approach of the ore searcher. In the qualitative part, the search for one “correct” answer to each question continued. As the interviews continued, the approach changed as a result of the experience gained from previous interviews. After a number of interviews, the approach was more like the traveller’s approach. As a result, the answers to the questions are not to be described as one answer to a question but as a description of how the response by the interviewee was recognised by the interviewer. This could be regarded as a step towards a postmodern constructive way of looking at knowledge and research[39]. The initial aim of quantifying most of the data received and finding correct answers did not work as expected. Consequently, there was a change in approach. The approach of the ore searcher was replaced by the intention of constructing meaningful relations and describing them to the reader.

The questionnaire was first handed out to each respondent so that they had time to find the information needed in order to be able to answer the questions. This also made it possible for the respondent to think through the explorative questions. After two or three days, the respondents were called up and answered the questionnaire over the telephone. The verbal contact made it possible to correct misunderstandings and ask follow-up questions for the explorative part of the interview.

Besides the pulp mills that answered the questionnaire, contact was also made with several other pulp mills in an attempt to gather information about exact volumes delivered to all the pulp mills in Sweden. The IT company for the Swedish forest industry (SDC), which is a non-profit organisation owned jointly by forest owners and the forest industry, was also involved for this reason. The SDC receives data and produces statistics on the wood volumes in Sweden.

[37] Kvale 1997, p. 118
[38] Kvale 1997, p. 12
[39] Kvale 1997, p. 12

The information gathered had to be separated into the different sorts of raw material received by the mills, round wood and pulpwood chips. It was also necessary to determine what kind of transportation was used in the delivery of the raw material to the industry because it affects the level of rationalisation that can be achieved with automation equipment. It was also of interest to obtain information about what measurement methods are used at each mill today and to what extent the different methods were used. This information had to be collected to be able to determine how beneficial for the mills a change in measurement procedure would be.

4.3 Presentation of results and analysis

The presentation of the results is divided into two separate parts. One part is a qualitative description of answers from the interviews and the other is a presentation of the calculations based on the answers obtained regarding volumes of timber received; number of employees and so on. When presenting results from qualitative interviews, it is unsuitable to mention the number of respondents who had answered positively or negatively to one question. Consequently, the purpose of the question is not to quantify but to describe whether a phenomenon exists or not. The use of words such as “all but one” or “four of ten respondents”, leads the reader to think that the figures respond to a percentage that can be applied to a wider population[40]. This aspect has been taken in consideration when presenting the results of the interviews. However, it has sometimes been considered significant to mention whether one or all of the respondents had the same opinion about a subject. These statements about the number of respondents who had replied with the same answer or gave diverging answers should not to be translated into statistical numbers and applied to all pulp milling industries or measurement organisations; they can, however, serve as a indication of the attitude of the industry.

The companies contacted expressed an interest in seeing how an investment in the automation of measuring would have a impact on mills. The companies were, however, not interested in having the actual conditions in their mills shown in this thesis. Accordingly, the mills are not named in the presentation of the results. They are given an abbreviation to describe which region they are situated in and also to describe their size. For the same reason the answers in the qualitative results are presented anonymously. The answers are presented as a summary of what has been discussed in all the interviews regarding each topic.

In some responses to questions about measurement procedures, an interval has been given by the respondent and not a precise figure. For example, the size of sampled bundles in southern Sweden could vary between 12 -14 m^3 and the time consumed to measure these bundles is 2-4 man hours. In these cases, an average has been used for the calculations. This might result in an indistinct picture of reality if the gap between lowest and highest value is substantial. It is uncertain how representative this method is because it has not been known how frequently different figures on the scale appear.

4.4 Method discussion

It is justified to have doubts about the snowball method[41]. It is possible that the companies contacted also have the same perception of reality. It is also possible that they exert other influences on each other. This could imply that companies not connected with the ones interviewed in this thesis are different. However, it would have been difficult to gain access to the amount of information needed for the thesis if the selection of pulp mills to cooperate with

[40] Trost 2002, p. 64 - 65
[41] Kvale 1997

had been more randomized. Regarding the explorative part of the questionnaire, it is sometimes hard to ask questions at the right level. The questions are intended to be open. Sometimes, however, it is impossible not to specify what subject you want an answer to. When questionnaires are sent out in advance, there is a risk of losing valuable information because the respondents focus solely on the questions and do not think "outside the box", which could possibly lead to more interesting and valuable information. Some of the questions had to be checked by the respondent in advance because of their nature. To avoid having the respondents focus to narrowly on the written questionnaire, follow-up questions were asked frequently during the interview.

4.4.1 Primary and secondary data

The data for the investment calculations have mostly been collected in interviews and therefore come from a primary source. In one case, regarding the average intake of round wood volumes to a mill, secondary data have been used. On this occasion, a statement from the company's chief executive (CEO) was used. In one case, the number of trucks delivering round wood each day to the mill has been calculated by dividing the round wood volumes received annually by the average load of each truck and number of days per year the mill was open for delivery instead of getting the figure from a respondent.

4.4.2 Reliability

Reliability means that the knowledge is compiled in a reliable way. Kvale discusses the interviewer's reliability in relation to conductive questions.[42] He states that if leading questions are used in an unconscious way, they can affect the answers. An example he gives is an experiment about witness reliability. Different persons watched the same movie showing two cars colliding. After the movie, they were asked about the speed of the cars. When the question was "what speed did the cars have when they crashed" the average answer was 65 km/h. When the question was "what speed did the cars have when they bumped into each other" the average answer was 50 km/h. [43]

In the thesis, the same questionnaire has been used for each interview and all the interviews were conducted by the same person. However, the knowledge of the interviewer regarding the subject of measuring has been accumulated during the work on the thesis. This might have affected the follow-up questions and led the respondent to give certain answers.

When it comes to quantitative research, reliability is the same as reproducibility and can be measured in numbers. The calculations made are reproducible. This means that it is possible to get the same results for the mills as long as the same assumptions are made regarding the possible benefits of the new measuring method.

4.4.3 Validity

Validity means that you have examined and measured what you wanted to examine. Validation is something that is performed regularly during the research process.[44]

An understanding of truth and validity is based on a belief in an objective world in a positivistic view of science. In a post-modern view of science, knowledge is regarded as a social construct of reality. Validity is created when competing interpretations and alternatives

[42] Kvale 1997
[43] Kvale 1997, p. 145, 212
[44] Kvale 1997, p. 212

ways of acting are being discussed.[45]Validation is dependent on regularly controlling and questioning the findings. Controlling means that the researcher has a critical view of the analysis and clearly reports on his/hers perspective on the topic being investigated.[46]

Questioning means that questions such as "what" and "why" have to be answered before the question "how". What does this thesis want to find out and why, prior to which methods will I use. The results of qualitative research interviews have been criticised for being invalid because the respondents can give false answers. The results of the questionnaires, the respondents' answers and the interpretation have been continually tested with information from other sources to determine the degree of truth and probability.

4.4.4 Possibility of generalization

Is it possible to generalize the results in this thesis to the pulp industry as a whole?
A statistic generalization can be made if the respondents have been selected randomly from a population. The respondents are not always selected randomly; instead, other criteria are used, such as availability, or as in the case of this thesis, persons with the competence to answer the questions asked.[47] Analytical generalization means that you estimate the extent to which an investigation can provide guidance in another situation. In this case, how the results can be used in pulp companies that did not participate in the thesis.

The approach of this thesis is to evaluate the change towards an automation of raw material measurement. The Swedish pulp industry is very large. Since the industry has been present for a long time in Sweden, there have been opportunities for development and evolution in various directions. This has led to a relatively diversified and heterogeneous group of companies and pulp mills. The large differences that exist must be taken into account when evaluating the results for the industry as a whole. The collection of data for all the companies was thorough. Interviews were conducted with persons at seven pulp plants, which corresponds to approximately 20% of the total number[48]. Given this heterogeneity, it is probable that this thesis does not cover all the aspects of an investment in automation for every mill in the industry. The aim of the thesis is to quantify the benefits of automated measurement to the Swedish pulp industry. As such, with the data used, it is a functional tool even if the full diversity of the industry is not described in detail.

The attempt to obtain information on volumes, transportation and measurement procedures used by the entire industry met with obstacles during the writing of the thesis. Some companies have the necessary information on their websites and some figures could be obtained directly when contacting the companies. Other companies were unable to share this kind of information and the SDC, which keeps a record of all transactions and statistics regarding the pulpwood industry, could not supply the information needed to fill in the gaps. The compilation of a true picture of the wood supply for the pulp industry as a whole therefore becomes indistinct. In a comparison with the total volume of pulp wood measured from the wood measurement counsel (VMR) in 2006, the results of the investigation made for this thesis differs by 20%, from a total 35 million solid volume beneath bark to 45 million[49] solid volume beneath bark registered at VMR. Three plants have been closed since 2006;

[45] Kvale 1997, p. 216
[46] Kvale 1997, p .218
[47] Kvale 1997, p. 210
[48] Skogsindustrierna 2006
[49] Virkesmätningsrådet 2006

Norrsundet, Stora Enso[50], Utansjö Rottneros[51] and Wargön, Holmen[52]. Other pulp mills have also cut production. This does not, however, explain the large gap between the results of the survey carried out for this thesis and the results presented by the VMF. Reliable figures have been obtained by the companies participating in the thesis. In the case of the remaining companies, the results of the investigation are regarded as being too unreliable to be used as a basis for calculations of effects scaled up to the whole Swedish forest industry.

One or a few persons at each mill have been interviewed. They were people with tasks and competence areas that were adequate for the questions. However, a change in measurement method affects many different units in a mill. It has not been possible to contact all these people. The thesis attempts to describe the change in measurement procedures for the mills although there are limitations in terms of the knowledge of the personnel interviewed. The respondent in his daily work does not handle some of the subjects of the questions. In these cases, the respondents have given answers but with the reservation that their knowledge is limited.

4.4.5 Handling errors

In the handling of data collected, there are a number of errors that can occur. These can be divided into three categories, handling errors, errors of analysis and interpretation errors.

In the handling and collection of data, errors are possible in the transfer between different media. When possible, some of the detailed interviews were recorded. This made it possible to go back to the source and verify that correct data were used. In other cases, a summary was made of what was said during the interview. In these interviews, there is a possibility that the written word could differ in meaning compared to what was said. In some cases, the questions were answered in writing, especially when the information transferred between respondent and interviewer was in the form of numbers.

4.4.6 Errors in analysis

There is the possibility of errors when making calculations. Such errors can result in mistakes in the handling of data as well as when drawing up formulas. During the work on this thesis, a large number of calculations have been made and the larger the number of calculations, the greater the possibility of error or bias. In view of this, a lot of time has been spent on both the construction of data sheets in Excel and going through the results and underlying calculations. Structuring large amounts of information is a complex matter; however, Excel and other spreadsheets make this work reviewable. This hopefully provides reliable results.

4.4.7 Interpretation

The results of the study are interpreted by the author. They are presented from the knowledge based on experience and information collected. Each individual has his/her own perception and interpretation of the results. What might be the correct interpretation from one perspective may contradict the perception of other persons.

[50] Kurkinen & Paajanen-Sainio 2007
[51] Rottneros 2009
[52] Holmen Paper 2008

5 Mapping of savings

This chapter describes the cost of the investment and the benefits to the pulp industry. The description of savings is made based on the responses from the interviewees. The interviewees are representatives of the seven pulp mills, the three measurement organizations and two logistics companies. The costs presented are based on interviews with representatives of Woodtech.

5.1 Benefits

The results from the interviews are not presented for each individual respondent but as a summary of what was said during all the interviews. How often some of the subjects were discussed will also be described. Since the aim of the thesis is not to describe unique pulp plants, the individuals making statements are not presented. However, when necessary for the context, a note is made of whether the statement was made by a mill or a measurement organization, in a certain geographical area or whether a comment is made from a large or a small mill.

5.1.1 Faster logistics

The argument that a faster measurement procedure benefits the production chain is the most easily accepted by all the parties involved, both the industry and the measurement organizations. The delivery of raw material to the mill varies over time and is hard to control on an hourly or even a daily basis. This generates queues when more than one truck arrives at the measuring station at the same time. In the case of all the plants except one receiving more than 100 trucks per day, queues at some time during the day are inevitable given today’s bundle measuring. There are also daily cycles of the trucks depending on their shifts on many of the plants. This results in extra high flows of logs early in the morning and in late afternoon at most plants. There are also annual cycles that result in the flow of raw material to the mill varying. For example, because of climate some roads are closed during the spring, which means that the inflow of raw material is higher before and after this period. In addition, before the summer vacation an extra stock is built up, which increases the pressure on the measuring station before this period. Consequently, most of the respondents see an advantage in shortening the measurement procedure in order to reduce the queues and the time trucks stand still at the measuring point. Most respondents also believe that a saved minute will translate into real money for the industry. There is a fee some plants have to pay the logistics companies when the delivery procedure exceeds a certain length of time. This fee is usually SEK 7 per minute. Pulp industry representatives believe that saving time would make it possible to reduce the amount paid to the logistics companies by the same figure. This aspect is a commonly used argument for converting from bundle measuring to the faster 5:2 measurement system in northern Sweden.

The normal system of bundle measurement is sensitive to queues since there is only a limited number of personnel at a given time at the measurement unit and they cannot be flexibly increased or reduced depending on the inflow of trucks. The procedure of weighing, measuring and offloading the load also has to take place in a certain order and no step can be accumulated for processing during periods when the workload is lower. In the northern district, the problem with queues at plants using the 5:2 method no longer exists. In the central region and in the south of Sweden all the parties agree that queues do exist and that one of the causes is the measuring procedure.

However, the size of this problem varies considerably depending on the size of the plant, the design of the reception area, if there are one or two measuring points and how even the inflow of raw material is. The answer to how long the average waiting time for a truck is varies between 0 – 20 minutes. There is also some uncertainty in the answers to this question. Even though most plants recognize this waiting time as a cost, they all have very vague knowledge about how much time is actually spent by the trucks in queues. Consequently, there is a degree of uncertainty in this figure and most answers are based on opinions from the wood supply responsible and not on actual studies. Two other aspects are worth mentioning regarding this subject. One is that two logistics companies were also interviewed in this matter in an attempt to verify figures received from the plants. What was significant in these interviews was that the truck drivers' opinion of waiting time was that it was double that stated by the personnel interviewed at the plants. When talking to people familiar with the measurement procedures in northern Sweden, the same phenomenon occurred. The logistics companies demanded a change in measurement at one site because of the waiting time, while other personnel at the plant or in the measuring facility did not see this as a problem. After changing to a faster 5:2 measurement system, all the parties agreed that there had been ineffectiveness before and that there was a considerable amount of money to be saved with the new method because of the time saved in queues and waiting. All the measurement organizations described the savings in time for the logistics companies as the single most important argument for a possible change in measurement procedures. However, one respondent questioned whether it is correct to translate one saved minute into a saved amount of money and scale this up to all saved time because of the investment. This person claimed that a truck driver drives approximately two times back and forth picking up wood on a harvesting site and delivering to the industry before he is replaced by another driver. If the driver saves 10 – 20 minutes a day, this will not translate into higher volumes to the mills. Since the duty cycles are so long and end at certain times when drivers are changed, the time saved is not accumulated and does not result in higher capacity. If the duty cycle were shorter, like when a harvester is cutting down trees, ten minutes saved would result in a greater volume being harvested because the operator has time to fell a few trees more before ending his shift.

Most respondents identified the measuring station as a bottleneck in the delivery procedure. There are other factors that also have to be taken in consideration when making the actual calculations such as what other bottlenecks will occur when reducing the time spent in measuring and the queues before entering the measuring station. Respondents mentioned that the lifting trucks unloading the raw material delivered could be a possible bottleneck. However, they all agreed that at least half of the saved time at the measuring station would translate into a veritable benefit for the plant.

There are queues at all mills using bundle measurement in the southern and Qbera regions, except for one of the smaller plants that did not identify the delivery logistics as a cost.

There is also another aspect of the benefits of more effective logistics. There are several mills that see an advantage in keeping wood stocks low. Especially TMP/CTMP plants that need fresh wood for their plants. These mills are not in favour of storing more than absolutely necessary to be able to supply the plant. It is also important to keep the mill running and production stoppages are not tolerable. A faster raw material inflow makes it less risky to keep a low stock since more trucks can deliver new pulpwood more quickly to the plant if necessary.

5.1.2 *Personnel*

The answers regarding the benefits of cost savings in salaries was mostly discussed with the measurement organizations because it is in their field. The opinion was that the workforce would have to be adjusted to the new circumstances. A majority could see benefits in reducing the workforce in an initial step. Not everyone, however, considered them to be as assumed since there would still be some human intervention when it came to measuring, estimating rot, bark and snow, checking ownership and rejecting trucks with dangerous contents in their load. A number of mills, however, thought that reducing measurement costs by reducing labor cost was good.

Few representatives of the industry as well as in some parts of the VMF organization have a vision for the measuring procedure. According to this vision, the pulp industry's measurements in the future will be carried out at a few central measuring units that receive all the necessary data from the mills. This could be possible with laser measuring equipment that determines solid volume and a number of monitoring cameras that determine the contents of the load, bark thickness, snow and so on. These central units could, according to the respondents, either be sorted by region or by company. For example, there could be one in Umeå for the northern region and one in Falun for the Qbera region or there could be one central unit controlling all wood intake for Södra and another one controlling Holmen raw material measurements. This would rationalize the work and at the same time keep the controlling work at the measurement organizations at the same level as today, assuming that the cameras give a good picture of the contents of the load. Since the measuring operators do not have to be physically present at the plant, it would then be possible to distribute the workload at a number of plants among a suitable number of operators. This would probably result in fewer operators. One of the reasons for this is the fluctuation in raw material flow that, even if it occurs in cycles at most plants, does not always peak at the same time at all the plants.

5.1.3 *Nightshift*

All the mills responded favorably, although with a few objections to the possibility of recording data from the laser equipment and using images from surveillance cameras from the nightshift for processing measurements during the day. It would be an advantage to be able to record the necessary data and process them during day. According to one source, nighttime measurements are twice as expensive as measurements during the day. The mills and the measurement organizations see solutions for when a truck load needs to be sampled and measured for the purpose of checking it. When a truck is randomly selected for this, it would be simple to notify the truck driver when logging in his load that his specific load would be control for the purpose of checking it. There is already space in the delivery area for this purpose where the truck can unload its load for later measuring. The loads are today marked with bar codes which could also be used in the future to determine the origin of the different loads. One of the most important objections is that there are no authorized personnel present to refuse entry for a truck containing materials that would damage production. The loads can sometimes contain coal, stones and plastics or metal that is harmful for production. Today, the measuring personnel are responsible for checking the loads for these contents. According to the respondents, if a truck delivers harmful material during the nightshift, it is not sufficient to discover this the next day when the data is being processed.

It is not common for trucks to bring harmful material to the plants but the consequences, however, are so severe that the risk has to be eliminated. The measuring standards today are normally also drawn up so that a truck with more than 10% of wood which does not meet the criteria is denied entry to the plant. Other agreements exist.[53] This measurement rule is also hard to follow if there are no operators present who monitor the delivery when the truck enters the plant. Another concern mentioned by both the measuring organizations and the mills is that there is possible uncertainty of how the ownership of the loads delivered to the mills is controlled. This problem occurs because a matter of principle, when it is not the independent measuring organization that determines and guarantee the ownership of each load but the truck drivers. Some respondents points out that not all the logistics companies have sufficient insight into the problems involving who is the owner of the load. The respondents, however, not only state objections to the suggestion but also offer solutions. Accredited logistic companies informed of the importance of correctly performed procedures or id-tagged logs with electronic chips from the harvest sites that are detected at the plant are examples of solutions. The ownership problem can also be solved. At least one of the plants interviewed receives chips, which are delivered and measured by weighing in unmanned measurement stations during the weekends.

5.1.4 Production benefits due to a higher information rate

As regards the information about incoming raw material, its importance seems to vary between different plants. One obvious reason for this is the difference in production of pulp. The Swedish pulp industry consists of both TMP and CTMP plants as well as sulfate and sulfite plants. The difference between these is that the TMP and CTMP process is more sensitive to the rawness of wood. It has to have the correct water content for the milling process to function correctly. Because of this difference, respondents from the TMP producers have said that a way of using a precise volume with the net weight of a load could give an indication of the rawness of the felled timber. The method of comparing measured volume with weight is already used at numerous plants. With an automation system this would be very rational. There are also TMP plants that prefer evenly sized logs with a low diameter spread for some of their milling processes. Making this selection automatic could also be a positive move.

The sulfate/sulfite pulp plants are relatively speaking less sensitive even though the raw material has some impact on their production as well. Information of interest for some plants is whether the wood comes from thinning or felling because of a difference in fiber character. This is also done today in some places when there is knowledge of the source of the loads. With laser measurement, all loads could be categorized and sorted according to their narrowing and diameter spread features into categories.

The importance of information on the loads varies among the companies, as mentioned earlier. Some respondents feel that all information that in some way can be used to describe fiber character is of importance. Growth ring width is also discussed as an important factor together with lightness of timber. On the other hand, one respondent responsible for raw material states that there would be no tangible benefits at all for additional information about fiber character. One mill representative states that efforts to collect and systemise data would not generate benefits in production. Apart from two plants that, according to the respondents, do not have anything to gain in production from detailed and reliable data describing the incoming raw material, all the other plants state that this would be of interest and beneficial for the production unit. Apart from the characteristics mentioned above, some of the respondents also state that there might be a lot of information stored at no cost today that could be of importance in a future analysis of the effect of raw materials on the products

[53] Högberg 2004

produced. They add that all exact information about diameters, narrowing, diameter spread and crookedness could result in better opportunities to control the processing and tune production. However, determining benefits of this kind in monetary values today is hard.

5.1.5 Less sampling

The question of reducing the need for sampling in bundle measuring due to higher repeatability and lower standard deviation for laser measurement was an issue that resulted in mixed answers from the measurement organizations. One aspect pointed out as an argument against a decrease in sampling is that when using automated measuring a number of subjective observations and estimations are still made by humans and this would imply that at least at the beginning, the sampling rate would have to be fixed. On the other hand, the northern region uses a method with less standard deviation and states that the hardest to subjectively judge is the wood volume percentage. Consequently, they can reduce the costly sampling rate even if there still is a procedure of human subjective determination of tree species and diameter spread. A decrease in sampling with equipment measuring precise volume is clear to most involved parties and if the automated measurement equipment proves to be accurate, a reduction in sampling is likely.

5.2 Other aspects

Both pulp industry representatives and respondents from measurement organizations have mentioned a few other concerns regarding the approach to an automation of the measurement process. One is the need to synchronize the data transfer between the new technology and VIOL. Since the technology is new, one respondent saw an extra cost in making the information from the automatic measurement unit accessible to VIOL. Another concern mentioned by one of the respondents was involved the most practical method of loading the trucks. According to the respondent, it is most practical when loading logs of variable length to place the longest logs at the bottom and along the sides of the truck and the shorter ones in the middle. The reason for this procedure is keep them better in place. This could become an issue since if this is a fact, the logs would not be randomly spread in the load. This could make automatic measurement less accurate since it measures the frame logs in the load and applies their features to the rest of the load.

Another future area of use mentioned during the interviews is the ability to measure both pulpwood and sawn logs in the same measuring station. In the interviews, with representatives of the industry, it was hard to get a straight answer regarding this matter. In the case of some mills, the respondents are unable to give the information due to business interests or lack of sources. Others refer to the preference of the owners, in this case stockholders and some point out the fact that it is generally hard to raise money for any investments at all at the moment.

6 Investment calculation and sensitivity analysis

In this chapter the calculation and costs from an investment are described.
The investment analysis is based on data collected during the interviews. Since some of the benefits of automated measurement are hard to estimate, two categories have been selected for inclusion in the analysis. The time saved for the trucks by rapid measurement is used as the strongest argument when switching to the 5:2 measurement method in the north of Sweden. It is also possible to estimate the benefits of a saved minute in SEK. Although no thorough study has been made by the mills of the exact waiting time for the trucks, all the companies have been able to give an estimated waiting time. The other category included in the analysis is the reduced cost of labour, which also is possible to estimate. The labour cost is known and the manning of the measurement unit with and without automatic measurement is also known.

As regards the mills from the northern region in this study, the smaller mill is situated in the region that applies the 5:2 measurement method. Representatives of this mill state that they have no queues. The larger mill in this region is situated farther south and does not use the 5:2 method. It has, however, not been possible to obtain information about the waiting time or time for measurement for this mill and values for savings in time for trucks have therefore not been included in the calculation.

6.1 Costs related to installation

The investment in measurement equipment of the kind used as a reference in this thesis is made in stages. The actual machine is delivered as one component; after this, installation and calibration are separate events. The groundwork and electricity supply is delivered to the site by the mill making the investment. The cost of all the measuring equipment including installation and calibration to make measurements as exact as necessary to satisfy the Swedish criteria would be approximately USD 400 000. The annual average cost of a US dollar in 2008 was SEK 6.58. The average for Jan – Mars 2009 was SEK 8.40[54]. The current global downturn does not simplify financial calculations, nor does it improve their reliability. This should be evident from the way the currency exchange rate fluctuates. The change in the exchange rate increased the cost 28% in the first three months of 2009 compared with the average for 2008. In this thesis, an exchange rate average of the averages for the last three latest years is used, i.e. the average for 2006, 2007 and 2008 divided by three, which results in an average cost of one US dollar of SEK 6.9.

The groundwork is relatively simple. The measuring equipment has to be attached to a frame structure, which the trucks are supposed to pass through when measured. The ground where the frame is built has to be flat and paved for a good result when measuring the truck load. Many of the pulp plants today weigh the trucks before they enter the plant to determine how much to pay logistics companies. This area is very suitable for the installation of the measuring equipment. The truck drives slowly when entering and exiting the weighing area and a flat paved area, which is necessary, already exists. The work that has to be done for the installation of the equipment is supplying electricity and providing connection points on each side of the road for attachment to the measuring frame. The cost of this is approximately SEK 100 000[55]. Companies that do not weigh the trucks and have no suitable paved area where the

[54] Riksbanken 2009
[55] Yourston (Oral communication)

trucks enter the plant will have a higher initial cost in addition to the actual measuring equipment.

In the calculations, it has been difficult to determine from when the cost of the investment should be counted. According to the manufacturers, payment is made in stages until the equipment is up and running, i.e. one initial payment and two or three payments at different stages. To facilitate the calculations, payment of the machine is regarded as having been made day one. Consequently, the cost burden on the cost side is higher than in reality since some of costs also should be discounted back to the initiation point. Since there is a start-up phase of six months for the installation during which time the measuring equipment cannot be the only method used for deciding payment, the losses during this period must be taken into account in the calculation. The discounted benefits for the first year are thus reduced by half of the savings for the first year. This seemed the fairest way to address this reduction in savings due to the start-up process.

6.2 Benefits related to an investment

The savings in labor costs are calculated by taking the cost of the employees prior to an investment and the cost of the personnel after the installation of the laser measurement equipment. The cost per employee per hour is the same before and after the investment. The benefit accrues from a reduction in manning. According to the interviews, the number of trucks received by the mills per day varied between 58 and 166 trucks. According to the manufacturer, the laser measuring equipment should be able to handle 200 trucks per day with one operator. All the mills have measuring operators working three shifts per day; one night shift and two day shifts. If there were two operators on each shift before the installation, presumably only one would be needed after automation. The cost of one hour during the day shift is SEK 275 including taxes and employer's contributions. Nightshift hours are more expensive and an additional SEK60 are added to the cost of all shifts when applying night shift measuring. The cost reduction per day is then multiplied by the number of days that the mills receive raw material.

At the larger mills, there is often one person who is the contact person for the measurement station. In cases where there is a contact person or one of the operators is working partly as contact person, these persons have also been included in the workforce when using automation measurement in the calculations, since this assignment would not be affected by the investment. The answers from the interviews are the source of information about the average waiting time for trucks today. The amount of waiting time that could be reduced by faster measuring is also extracted from the interviews and varies significantly between the mills. The cost of one minute standing still is set at SEK 7 and using figures, it is possible to obtain a value of the saved time in smaller queues.

There is also a reduced cost for the trucks in the actual measuring. The time for measuring trucks in the normal way takes 10 -15 minutes although it varies a little between the regions because of differences in the contents of the load. In the southern parts of Sweden, there is often more than one owner of the wood on each truck. The more fragmented the load, the longer it takes to measure the trucks. In the calculations, the measuring time is set at 12.5 minutes in the southern region and 10 minutes in the central region. In the north, most of the plants have nothing to gain from faster measurement because they use the 5:2 method, which is as time effective for the trucks as is laser measurement.

The benefits from savings in waiting time are then multiplied by the average number of trucks received per day for each mill and the number of days per year that the plant receives raw material. The two categories of cost reductions are then summarized as the annual benefits of an investment. These results divided with annual consumption of round wood are presented in Table 1. In this table, only the savings are included. The cost of the investment and its effect on the investment will be included in the net present value calculation in this chapter. The cost is not included since this calculation shows the cost reduction for one year. The cost of the investment has to be distributed over all years that the equipment is used.

Table 1. Cost saves in sek/m³ per mill

Region	Round wood intake	Abbreviation	SEK/m³
South	1,500,000	S: 1.5	4.78
South	800,000	S: 0.8	6.64
Qbera	850,000	Q: 0.85	3.41
Qbera	750,000	Q: 0.75	3.65
Qbera	600,000	Q: 0.6	3.00
North	1,000,000	N: 1,0	2.69
North	1,700,000	N: 1.7	2.77

The regional differences are evident in a comparison of savings between the mills. The mills situated in the northern region have least benefits per m3f ub and the mills in southern Sweden have most benefits in an investment per m3f ub. It was, however, as mentioned earlier, not possible to obtain values of measuring time and waiting time for the larger mill in the north that did not use the 5:2 measurement method. There is no obvious trend regarding the size of the mills and the benefits per m3f ub of an investment. The size of the mills is, however, important in terms of the total benefits of an investment, as will be shown in the net present value calculation. The mill making the largest savings in SEK/m3f ub is the smaller plant in the southern region. This mill has the largest problems with queues of trucks of all the mills in the study. Regarding the manning of the measurement station, this mill's costs are proportional to the other mill's costs in the same region.

In the standard calculation of the NPV, the investment horizon is set at 5 years and the cost of capital at 10%. These figures will later be altered in the sensitivity analysis. The savings the mills make every year due to the installation are discounted back to the point of investment and reduced by the cost of the measurement equipment and installation.

Table 2 Net present value of a standard setting calculation

Pulp mill	Million SEK
S: 1.5	20.94
S: 0.8	14.08
Q: 0.85	6,59
Q: 0.75	6.31
Q: 0.6	3.30
N: 1,0	5,97
N: 1.7	12.64

With the standard settings of investment horizon and interest rate, all the companies benefit from an investment, Table 2. There are, however, large differences, both geographical and because of the size of the mill. As regards the size of the plants, the larger plants have much to gain from an investment, according to the results. The larger the plant, the more volume to divide the cost between. There is, however, an upper limit to this. The largest plant in the investigation receives an average of 166 trucks per day. The maximum for the measurement equipment to receive each day with 100% efficiency is approximately 200 trucks. If the flow of trucks exceeds 200 trucks there would either have to be an increase in measurement personnel or the trucks would have to start waiting for measurement. There would still be benefits for a larger plant installing automatic measurement equipment but the savings per m3f ub would not remain as high when the mill reaches more than 200 trucks per day. The mill with the lowest consumption of wood is also the one mill that benefits the least from an investment. This mill still saves almost SEK 3 million over a 5-year period. It is, however, harder for this mill to make the decision to invest or not since the margin for a positive outcome is lower.

As can be see in the table, one the benefits is the greatest for the companies in southern Sweden. The measurement method is the same in the Qbera region and in the southern region but the benefits are notably higher in the south. What differs between the both regions, according to the interviews, is the diversified supply chain in the south with many small suppliers, which results in more work for the personnel in combination with longer waiting time for the trucks.

There is a large difference in earnings from an investment between the two plants in the north. The savings are more than twice as large for the bigger plant and it has a 70% higher intake of wood. In the southern region, the larger plant earns 50% more and has a 85% higher wood intake. The difference is much larger in the northern region than in the south when comparing only wood intake. The two mills in the north gain no logistical benefits in the calculation. The only difference between the two mills is that one of them uses the 5:2 method when measuring raw material and the other uses standard stack measuring on trucks.

6.3 Sensitivity analysis

In this sensitivity analysis, the standard results are altered to see which parameters have the largest impact on the results presented in the previous chapter. First, there will be a discussion of what parameters to alter and then the results from the calculations will be displayed with a discussion of probable reasons for the results found.

6.3.1 Finding key indicators

To find key indicators, one must have knowledge both of the possible variations in the numbers and the impact of a change in the results of the calculation.

Indicators used in this analysis are:
Interest rate and investment horizon.
Variation in used cost savings

One key indicator is the investment rate used for the NPV calculations. As we can see, the financial markets around the world are not as predictable as would have been preferable when making the forecast and the investment calculation. In these uncertain times, it is especially hard to make statements about the accepted rate of return for investors. It is also hard to make a specific forecast about the cost of loans to companies and to make statements about WACC.

Research done by Löfsten[56] in the late 1990s shows that the average rate of return in the Swedish pulp industry was 18 – 20%. This is the latest figure available for the industry as a whole and seems out of date today. The representatives have been asked questions regarding this matter. Some of the respondents have given straight answers, which unsurprisingly have been below the figures presented by Löfsten. Others did not know the interest rate used in calculations by the company. Another group would not answer this question but did say that the interest rate used by the company was well below 18% – 20%.

The stock market is relatively unstable and it is difficult to foresee developments for the pulp industry and their return on capital. All companies researched are also not listed on the stock exchange, which makes it difficult to use WACC. This because it is hard to determine in a fast and simple way what interest rates other owner categories demand.

In order to enable the majority of the companies in the pulp industry to use the results the interest rate is used as a key indicator in the sensitivity analysis. The results of the investment are shown at various interest rates in Figure 2. This makes it possible to see how dependent the outcome is on the current interest rate and the companies can apply the rate closest to how they perceive their reality. The rate of return also plays a more important role the longer the economic lifespan of the investment.

In the second sensitivity analysis another comparison was made. This analysis compares the standard set condition with results in the calculation where various sources of cost savings have been removed.

6.3.2 Variation due to change in cost of capital and investment horizon

In this first sensitivity analysis, the impact of a change in investment horizon and interest rate is tested. Figure 2 shows the net present value of the investment for each mill with the standard setting as the green graph. The impact of a change in investment horizon is tested by raising the investment horizon to ten years as well as lowering it to only three years. The impact of this is shown in the two blue graphs. The impact of a change in interest rate is tested by raising the interest rate to 20% and lowering it to 5%, which is shown in the purple and red graphs.

The first sensitivity analysis shows that the most important factor of the ones tested is the anticipated economic life of the investment. If the technique starts to be used in Sweden on a larger scale, the odds are low that a change in the measurement procedure will take place. Consequently, the risk of a need to change equipment is relatively low. Since the formulas underlying the estimates of solid wood content in the loads are continuously updated via sampling, the accuracy of the machine will improve over time. There are also no moving parts in the equipment and no obvious parts where wear would be significant. Because of this, the length of the investment horizon will probably be long. It is clear that it is harder for the smaller mills to carry the investment. With a 3-year investment horizon or a high interest rate of 20%, the margin for a positive result at the smallest plant is very low.

[56] Löfsten 2002

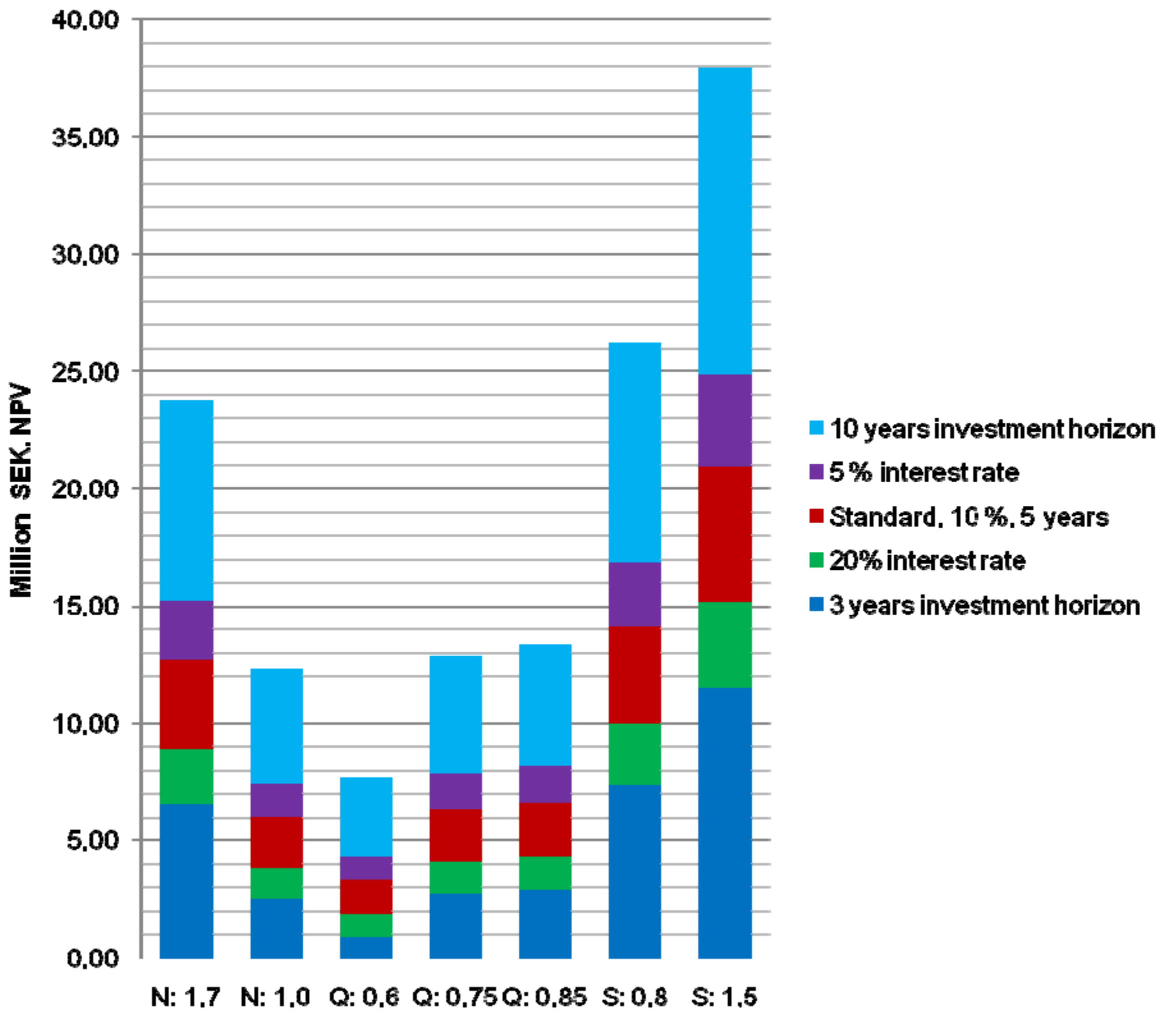

Figure 2. Variations in NPV of investment depending on interest rate and investment horizon

6.3.3 Change in result depending on accepted sources of cost savings.

The first sensitivity analysis shows that the investment is profitable for all the mills with a tightening in both investment horizon and raised interest rate. The investment is more profitable for the larger mills than for the small ones. To further investigate the results of the calculation. the savings categories where removed from the calculation one at a time. In the interviews, some respondents were uncertain about what cost reductions could be made. This sensitivity analysis should give a good answer to the dependence on which sources of cost savings that are necessary for a positive outcome of the investment.

The cost of logistics has no impact on the investment analysis as far as the northern region is concerned since the measurement method currently used there is effective. This results in no queues and lower logistics costs since the trucks more effectively pass through the measurement facility.

As the results show, an investment would be beneficial for plants in all the regions. In the southern region and for the larger plants in the Qbera region, an investment would be of interest even if no benefits in labor cost savings were included. Plants in the northern region are more sensitive to the possibilities of reducing labour. The results from this region are less predictable and the reason for this region breaking the trend is two factors. Firstly, their logistics benefits, which are possible with automated measurement have already been obtained in this region. Secondly, according to respondents, there has not been any reduction in labour due to the 5:2 method, which means that the calculation model treats the possibility of reducing labour in this region the same way as in the other regions. This is in reality questionable. The most northerly region, with the smaller of the northern mills, would probably not have as much to savings in labour costs as diagram 2 suggests.

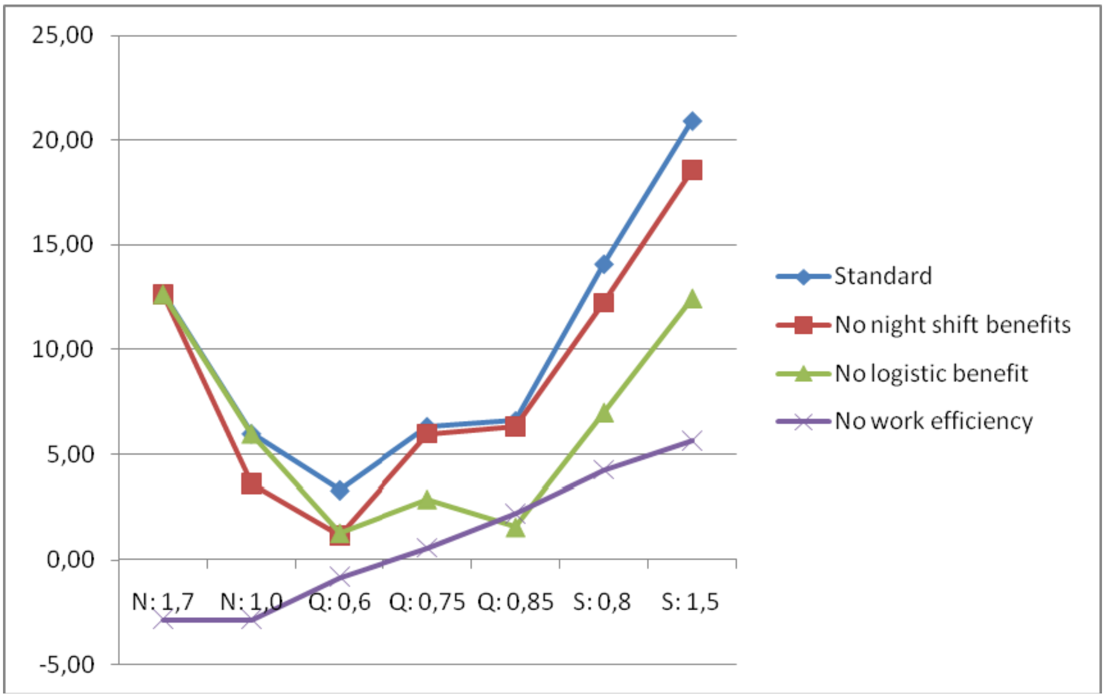

Figure 3. Variation in NPV depending on realized predetermined cost savings.

The largest mill in the northern region is the only one that does not have a night shift today. This explains why it has the same level of savings, both with and without the benefit of closing down the night shift, see Figure 3. The reduction in the cost of labour is the single most important benefit for all mills except the largest one in the Qbera region. At this mill, the logistical benefits are equally important for a positive outcome of the investment.

6.4 Discussion of monetary results

For most medium-sized and large plants, it is possible to justify an investment either by accepting the presumed savings in working hours for the operators or the logistical benefits by gaining more time for transportation and less time standing still for all the trucks delivering wood to the plant.

There is one result from the calculation that appears to be a bit confusing. The results from the northern region show that the investment is rather beneficial. This plant already has a more rapid measurement method then the others. The measurement cost per cubic meter is also significantly lower in the north today compared with the other regions. The answer depends on results from the interviews where respondents replied that while there were no benefits in terms of workload, the cost of logistics was lower when using the 5:2 method. Because these plants have the same workload today as they would have using the other method, bundle measurement, automation in the calculations appears to be equally beneficial in the north with respect to the workload as in the south. It is notable that the cost of measuring as a whole is lower in the north with the difference in measurement technique being one significant factor between the regions. Because of this reasoning, a change in measurement method in the northern region might not be more effective in terms of reducing the workload due to a slimmer operation today than is shown in the calculation.

According to the results from the standard calculation, the benefits per m3f ub are lower in the northern region than in the rest of Sweden. One probable reason for this is the use of a more time-efficient measuring procedure, i.e. the 5:2 method.

The calculations are not a perfect description of reality. As mentioned earlier, small plants relatively speaking are less represented in the investigations. It is possible that the calculations would change dramatically in the case of mills that receive less than 600,000 m3f ub of round wood since it is probable that they would not gain any benefits from savings in personnel. If only one person is needed each shift today, they would have to have the same manning after an investment in measurement automation equipment.

When evaluating the results of the savings made per cubic meter, it is noteworthy that this calculation only shows savings and no costs.

It is hard to dismiss the results of this thesis. According to most of the respondents, the benefits discussed are possible to realize. The calculations show that the investment would have a positive outcome even with tough constraints in investment horizon and cost of capital.

7 Discussion

The results of the research reported are positive. The risks that could have an impact on the outcome of an investment are largely due to the fact that it involves new and, in Sweden, almost untested technology. Because of this, there is a risk in the start up phase. The investment is depending on how easily the technology complies with the measurement regulations that exist today. The prospects for the implementation of this new technology, however, look good. Since this is new technology in Sweden, it is uncertain how well a divestment of the equipment would work if a plant had to close down. Both these risks could be reduced if an initiative to change were to come not from one company but as a joint initiative from the industry. The risk and cost of introducing the technology would then be spread among more companies and it would send a strong signal to all the actors on the market about what would be to expect from the future. This would also speed up the change. If the industry adopted this measuring technology, it would also be easier for a company to sell it if it had to close down.

The laser measurement system can be installed and adapted to Swedish conditions and benefit most plants. To get real leverage in the investment, it is important to not only try to adapt the new technology to the present conditions but also to be willing to adapt parts of the measuring to receive all benefits of the new technique. The truck drivers could be more trusted and there would be a potential for creating an accrediting system so that they are as reliable in their judgment of whether there are any contents in the load that are dangerous for the mills production. After all, they are the ones doing the loading and should therefore be suitable when it comes to determining the contents of their entire load. Since all deliveries are recorded and saved, it would also be possible to determine at least with some certainty who delivered a load that should have been denied entry. Another possibility in this case would be that the measuring procedure during night and why not all day be, as proposed by respondents, carried out at central units in the measurement districts. This idea could be taken even further. The fact that the measuring process can be moved from the actual site opens up a variety of possibilities. In this way, the new technology could also save costs for the smaller measuring sites. They are the ones utilizing their personnel least effectively. Even if only one truck per hour arrives, there still has to be someone there measuring it. New and reliable technology could make it possible to concentrate these ineffective sites to one unit in each region.

In an extension of the automation there could be a possibility to move the measuring process from the actual plant sites. Such possibilities open up for visionary thoughts. If it is acceptable to use laser measurement to determine volumes and cameras to evaluate the other necessary properties of the wood, why not move the measuring process to the place where it is most cost effective. In a distant future, the work of measuring pulpwood could be performed in India or whatever country that could supply the service cost effectively. If this is too visionary it might at least be possible to have Swedish personnel to measure the received volumes from night shifts from an office open during the day in Sydney. The same way as X-rays are examined by Swedish doctors in Australia.

It is not a question of whether it is possible to make these rationalizations or not, but whether the incentives are large enough to make the effort worth while. As the thesis shows, there are substantial amounts money involved and the investment in itself is, in comparison with other investments in the industry, very affordable.

If the industry in Sweden were to start using the same unit for measuring wood as in Finland, cubic metres solid volume inc. bark, the effectiveness of an investment would be even greater. The operator would not have to subjectively determine the occurrence of bark. The measurement equipment would automatically indicate a precise volume including the bark. Bark has a value today with the current high bioenergy prices. The price paid for the wood could also be adjusted to the new unit of measurement. A change of measurement unit would also raise the incentive to keep the bark on the logs. This would have a positive effect on the freshness of the wood since the bark protects the logs from drying.

An interesting extension of the automation of measuring could be to start measuring sawlogs with the same equipment. This is especially interesting in situations where the saw mill is situated next to the pulp mill since sawlogs already are measured in stacks to some extent.

7.1 Further investigations

This thesis focuses on the key factors for the investment in equipment and does not describe in detail the effects on one mill. It is up to each mill to apply the factors to obtain an indication of how beneficial it would be for their plant. However, there are a number of factors to take into account and investigate thoroughly if one wants a more detailed picture of the consequences of an investment. For example, it is important to know exactly how long the standard waiting time for trucks is, how even the inflow of raw material is and what bottlenecks other than the measurement process exist in the case of raw material logistics. Accurate information of this kind would provide a good basis for an estimation of the impact of automated measurement on logistics costs. There are a few companies that have some of the answers to these questions, which means that there is a knowledge gap that would be of interest to fill. Because of the large number of trucks delivering wood each day, a difference of a few minutes is of monetary importance. The average plant in the thesis receives approximately 27,000 trucks per year. One saved minute per truck for the average plant would result in a saving of almost SEK 200 000 saved per year. This calculation presupposes that it is possible for the mill to gain the SEK 7/minute that a truck costs when standing still. The plants often have good statistics on the whole delivering sequence since the trucks drivers usually register before entering the weight and also register when driving off the weighing machine after delivering. This tool is, however, too imprecise to be used for an investigation of the impact of a change in measurement since it does not specify where in the delivery chain the waiting time occurred. It could, however, if accessible, be used to obtain figures on best case scenarios with the technique used today. It is up to each plant to reflect on the intake in order to make calculations about the size of benefits from a switch to automation measurement; i.e. to establish whether there is any waiting time today, how long it is and where the bottleneck occurs. This investigation would require several time studies over a year on site at the mills to cover all aspects of the complexity of variations in raw material delivery.

In the same way, it is hard to say exactly what the impact would be on the workforce involved in measurement. Here, as in other respects, the industry is heterogenic. Some plants receive more during the night, some have a more even workload then others. Consequently, there are many aspects specific to each plant that determine the potential for saving. It is possible to evaluate these actual changes that would be made specifically at each plant and it could point to the concrete savings for that plant.

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Appendix

1. Questionnaire for industry

Short questions

Witch measuring methods are used today and to with extend are they used?

How is the raw material intake shared over different suppliers, companies collectives private forest owners?

Trucks per day and days per year with measuring?

Average waiting time for trucks, before measuring?

Average cost for driver and truck, per minute?

What is the average interest rate at your company for these kind of investments?

What economical life length would you consider a Logmeter to have?

Developing questions

1. What are the possibilities to collect data during night time delivery for processing during daytime? Which would be a possibility with use of the Logmeter.

2. How would you solve the control measuring?

3. In witch ways would a greater knowledge of the raw material, like diameters and crook be beneficial? In witch ways would it effect production?

2. Questionnaire for VMF, divided in to each plant

Short questions

1. Yearly intake?

2. Cost for measured volume in work time sorted by way of measuring and other cost posts?

3. Cost for control measured volume in m3, sorted by ways of measuring from previous question?

4. Measuring time per truck?

5. Average volume per truck?

6. Number of shifts and employed each shift?

7. Costs per employed in measuring?

Developing questions

1. What is your opinion regarding the possibilities of using a Logmeter in your measuring?

2. What is your opinion in manually note bark thickness and snow?

3. Witch would be the need of sampling and control measuring with an automated of measurement procedure, is a reduction possible?

4. Is there a possibility to have measuring personnel working only during day time and during night time only collect data for later processing? How would you like to solve the control measuring?

5. In witch ways would an automation influence the working environment for your employees?

6. What effect would a Logmeter have on the efficiency of measuring?

7. Do you think there will be a change in measurement unit to dry density? When?

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